CONSERVATION FOR PROFIT

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All agrologists have placed the concern for soil degradation on or near the top of their priority to act list. There are two questions I address today. First, can we afford not to make it the number one issue. The reason is that agriculture researchers warn by the year 2000, soil degradation could rob prairie farmers by as much as 6 billion dollars. They also warn us that if soil degradation is left unchecked we could ultimately devastate our soils within 10 generations. The solution is not a new chemical. It isn't even a new theory. It is a matter of re-orienting farm land management: from farming for profit...to...conservation farming for profit.

The second question that must be answered is why we at Hoechst have taken on soil conservation as a major promotional thrust. The answers are very basic. First, it is to maximize land available for crop production and to ensure that productivity on this land continues in the future. Without a healthy farm economy companies such as ours would not exist. It is therefore our mandate to provide products that help conserve for profit and to also educate farmers how to use these new tools through the book Conservation for Profit and through presentations such as this one. We hope others will also see the immediate need to act so as to prevent further deterioration of prairie soils to protect our future. That is why at Hoechst we have committed so much time, effort and money to this issue.

What is at stake in soil degradation. There are three main concerns: erosion losses, salinization losses and nitrogen losses. Soil erosion losses can be through either wind or water erosion. The value of the losses are calculated using the cost of lost nutrients that must be replaced and the value of non-recoverable wheat yields that are permanently lost. It has been estimated that 277 million tonnes of soil is lost to wind and water erosion. The loss just in nutrients is valued at $239 million annually. In addition to this, it is estimated the value of non-recoverable yield is $129 million giving a combined total of $368 million annually lost due to erosion.

A second cost are the losses due to salinization. It is presently estimated that 2.2 million hectares of land are affected and that the salinization area is increasing by 10% per year. If one assumes that a crop will yield only 50% of its expected yield, this is a loss of 380 million dollars per year.

A third cost is the nitrogen that is lost due to leaching and/or denitrification. Losses of nitrogen by these mechanisms are 15% higher on summerfallow than on cropped land. If summerfallow was reduced by 40% this would save 62.4 million kilograms of nitrogen or $47 million annually.

So what are the CFP goals? There are 3 major goals:

1. Halt soil salinity
2. Reduce erosion by 50%
3. Reduce summerfallow by 40%

If one looks at the ten year benefit of accomplishing these goals it means a gain of 4.6 billion dollars. To an average 500 hectare farmer the benefits would be over $70,000 for the ten year period.

THE CASE AGAINST SUMMERFALLOW AND INTENSIVE TILLAGE:

Attitudes toward summerfallow and tillage are deeply ingrained in prairie farmers. However, it has been only in recent decades that the practice, its benefits and liabilities have been thoroughly assessed by researchers. I would like to deal with some of the concerns.

1. <u>Soil Structure</u>

The first area of concern is with regards to soil structure. A single cultivation can hasten soil water evaporation by an equivalent of ¼ to ½ inch of rainfall. If we take an average farmer in the Palliser Triangle who tills 8 times, the loss would be 2 to 4 inches during the fallow period. So the first tillage side effect is that yields are affected by soil moisture that is released by tillage. Drying soil with tillage also increases erosion susceptibility.

Another concern is that tillage tends to change aggregate size. Clod size is very important in considering wind resistance. So a second tillage side effect is that each successive tillage decreases clod size and stability, thereby decreasing resistance to wind erosion.

A third concern is organic matter loss. Soil organic matter is as important in its role of maintaining structure as it is in serving as a nutrient reserve and chemical buffer.

Table 1 summarizes total losses during the first 60 years of cultivation. These have been estimated at between 600 and 700 million tonnes of nitrogen. Further harvested grain used only 33%, while 26% was leached beyond the rooting depth and 41% was lost by denitrification and erosion.

TABLE ONE

Estimated rate of N released from soil organic matter under Prairie grain cropping over a period of 60 years.

	Mineralized (kgN/ha) annually	N(kgN/ha) 60 years	% of N lost
Released from soil organic matter	42	2,520	-
Sold off the farm (harvested)	14	840	33
Leached below the rooting depth	11	660	26
Denitrification and erosion losses	17	1,020	41

Source: Rennie et al.[1]

In less than a century, nearly half (40-45%) of the available organic matter has been lost from prairie soils. Two thirds of these nutrients were wasted by inefficient agronomic practices. Summerfallowing is, in essence, a mining operation which causes the breakdown of organic matter and the release of nitrogen. It leaves no source and no opportunity for replenishment.

TABLE TWO

Mechanism of Organic Matter Loss
in Summerfallow

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Mineralization of Organic Matter
Conversion of N to NO_3

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No Crops to Use Nitrate
It Accumulates

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Soil Becomes Wet
Excludes Oxygen

↓

Leached ←

Certain Soil Bacteria Activated

↓

NO_3 to N_2O
Lost to Atmosphere

In addition to microbial action, let us not forget that of all known causes of nitrogen loss, erosion and drifting are perhaps the most basic. A third tillage side effect is that tillage and summerfallow cause organic matter breakdown and waste organic matter nutrients. They rob organic matter of its two most important functions.

A fourth concern is the removal of crop residue. The two "golden rules" of erosion control have been coined as maintenance of vegetative cover and optimal cloddiness. Tillage breaks both of these rules.

The fourth tillage side effect is by removing vegetative cover you will expose the soil to wind and water erosion. Burying or mixing crop residues by tillage hastens decomposition and loss of organic matter.

A fifth tillage side effect is soil compaction. Tillage has resulted in higher bulk densities of surface soils. Higher bulk density is caused by the formation of finer clods that are more tightly packed than in undisturbed soil. These changes have resulted in decreased infiltration and percolation rates, giving cultivated soils drainage problems. Soil compaction (indicating poor tilth) not only restricts root growth but also affects aeration and soil/water status.

2. Erosion

The second concern is with soil erosion. Because of the effects tillage has on soil moisture and structure, summerfallowed soils are more susceptible to wind and water erosion. It has been estimated that 150 tons to 126,000 tons of soil per cubic mile of air may be transported by wind erosion. It has been also shown that up to 4 tons of soil per hectare per hour can be lost during intense thunderstorms.

As I stated earlier the soil losses due to combined wind and water erosion have been estimated at 277 million tonnes annually. The direct cost to the farm community was estimated at $368 million annually.

3. Salinization

The third concern is salinization. Salinization is a distinct form of soil degradation. It is not related to erosion or organic matter losses but has the same causes: summerfallow and intensive tillage. Research has shown that summerfallowing is an inefficient method of storing water. And it is this inefficiency, combined with the effects of intensive tillage which is a major contributor to the spread of dry and saline seeps.

In a summerfallowed field, the root zone can be filled to overflow capacity. The following table shows that from 52.8 cm of average precipitation that falls in Lethbridge region during 21 months of fallow period, 75% is lost by runoff, evaporation and deep percolation. Losses such as this certainly show the inefficiency of summerfallow for storing water and how they contribute to salinization.

TABLE THREE

Amount of soil moisture stored in 150 cm of soil under summerfallow

Lethbridge '69 to '74 (average)	Harvest to Spring	Fallow Season	Fall to Spring	Total
Precipitation	18.3 cm	18.0 cm	16.5 cm	52.8 cm
Stored	8.6 cm	1.5 cm	3.0 cm	13.1 cm
% Lost	53%	91%	81%	75%

Source: After Alberta Agriculture.[2]

CFP - THE FOUR CORNERSTONES

There are four major cornerstones involved to achieve the CFP goals. They are conservation tillage, zero-incorporation, managemelt and flexible cropping. The CFP program is designed so that the farmer chooses the options that work best for him. The key element to the CFP program is that it saves the farmer money while it improves soil tilth.

1. Conservation Tillage

Conservation tillage includes tillage systems that create as good an environment as possible for the growing crop and that optimize conservation of our soil and water resources consistent with sound economic practices. Conservation tillage is synonymous with maximum or optimum retention of residues on the soil surface and the utilization of herbicides to control weeds where tillage is not or cannot be performed.

The short-term benefits of conservation tillage are less erosion and cost savings. The soils are less erodible because of increased trash cover, larger clod size and increased surface moisture.

There is no question that conservation tillage demands more management skills. Residues on the soil surface can make it more difficult to achieve good seed placement. Increased knowledge of weeds, insects and the products and ways to control them will be necessary.

The farmer will have to monitor and keep accurate records on each individual field. He will have to make choices with regards to chem-fallow and tillage combinations. Conservation tillage and the economics of chem-fallow vary with each farmer. He must look at different types of equipment. All these factors must be carefully weighed before decisions are made as to what degree conservation tillage can be implemented.

What are the economic aspects of conversion to conservation tillage? First one must weigh the costs of these increased management skills. There are generally three areas of costs to consider. These include direct fees paid for subscriptions and tuition fees for courses in conservation tillage. There is also the value of the time spent learning about this new approach. Finally there is the cost of learning - maximizing benefits while minimizing mistakes. When looking at the broad picture of conservation tillage the above costs are minimal and most farmers demonstrate a desire to adapt to changing technology.

A second area to look at is labour costs between the two systems. Alberta Agriculture has estimated that on average a 500 hectare farmer uses his tractor 600 hours. It has been suggested that converting to conservation tillage could reduce his tractor hours by 25 to 40%. If we use a conservative cost of $5.00 per hour this would save $750-$1,200 per season.

The decrease in number of operating hours will save in the amount of fuel used. Using a value of .36¢ per litre for diesel and a fuel savings of 11 to 34 litres per hectare, a farmer would save $3.96 to $12.25 per hectare. On a 500 hectare farm the savings would range from $2,000 to $6,000.

Research shows that machinery operating costs in conservation tillage systems are reduced. An extensive study done in the Northern Plains isolated machinery operating costs as the greatest area of savings. In this study, a savings value of approximately $25 per hectare was suggested. Thus for the 500 hectare farm savings from reduced equipment costs approach $12,500.

It is difficult to establish the value of the added expense for fertilization to conservation tillage. However if you had to increase nitrogen fertilization by 20 or 25% you would be looking at an increase of $8.13 to $10.16 per hectare (assuming a standard application of 66 kg/ha N, at .62¢/kg). On an average sized farm, the cost increase ranges from $4,000 to $5,000.

Finally there are the possible increases in use of insecticides and fungicides. Certainly in Western Canada these areas make up a small percentage of the pesticide costs. It is reasonable to assume that increased costs in these areas will be negligible and sporadic.

In summary, the range of benefits and considerations with conservation tillage can be broken into short and long-term. Short-term benefits are found in reduced labour, fuel and mechanical requirements. In situations where profit margins are small, all savings factors become important. In the long-term soil quality will improve and less chemical fertilizer may be required.

Research into conventional versus conservation tillage indicates that generally speaking yields are similar. Because conservation tillage can reduce erosion by 50 to 90% it is clearly preferable to intensive tillage.

2. Zero-incorporation

The second cornerstone of CFP is zero-incorporation. As previously shown, tillage is the over-estimated cure and underestimated problem in prairie soils. Even with todays overwhelming evidence against it, intensive tillage still occupies the major part of most Western Canadian farmers' management practice.

Weed control is given special emphasis in CFP. You could put a lot of effort into improving the soil, but if you neglect weeds the yields will suffer and the efforts will be in vain. So the question is not if one must control weeds but to which system should they turn - post-emergent vs. soil incorporated control.

There is a lot of controversy about when weeds begin to compete with the crop. Many scientists have conducted various trials trying to give all of us the definitive answer. To date the controversy continues, but when products such as Hoe-Grass are used the studies often show the Hoe-Grass treatments out-yield other pre-emergent and post-emergent treatments.

There are a lot of factors that contribute to maximum yields. Weed control is an integral part but not the only reason for high yields. Seed bed preparation is critical. Reduced tillage will increase available soil moisture and a firm seedbed will enhance germination. Is the crop sensitive to phytotoxicity from the product/products being used? When is the product used? If fall applied have you lost snow trapping ability and thus moisture? If a product is applied in the later leaf stages of a weed, how much competition has taken place? All of these factors plus others must always be considered in the final assessments.

Zero-incorporation herbicides offer both agronomic and economic advantages and are strongly recommended in the CFP system. Post-emergence herbicides require no adverse tillage operations for application. This allows farmers to take the first step toward sound soil conservation practices for profit, without compromising yield or weed control.

3. Snow Management (Managemelt)

Up to 1/3 of the annual precipitation on the prairies falls as snow - yet the vast majority of farmers take no special steps to keep their rightful share. The moisture gained from snow management could give many farmers the opportunity to extend their current crop rotations.

It has been suggested that by improving moisture conservation efficiency from 50 to 75% in the Dark Brown soil zone, farmers can conserve an additional 50-60 mm of precipitation in the first winter period. As much moisture would be conserved in this first winter period as during the remaining 12 months.

The challenge and the potential of snow management is this simple: using the best snowtrapping and management techniques, a farmer should be able to accomplish the same moisture storage as with summerfallowing, in only 8 months instead of 20 - and increase production on stubble up to 20%.

It has been discovered that the 20 month conservation efficiency for summerfallow ranges from less than 10% in the Black and Gray soil zones, to 25% in the Brown soil zones. Therefore summerfallowing with intensive tillage is wasteful and counter-productive when used for moisture conservation, also the poorly utilized water leads to many soil degradation problems. These include the dramatic increase in salinization, increase in nutrient leaching and increased potential of water erosion.

Therefore, the snow management objectives are to first trap the snow so that it is distributed over the entire field. Then to keep it on the field and finally when it melts for it to become soil water. Managemelt depends on conservation tillage and zero-incorporation to work.

There are various managemelt techniques which include non-competitive and competitive barrier systems. These vary from highly variable results with snow ridging to more successful systems as swathing at alternate heights.

Swathing at alternate heights has been investigated for 10 years at Swift Current. The advantages to the system are that no further operations are required and swather attachments are simple. It has also shown to trap a significant amount of extra snow over uniform stubble as shown in the following table.

TABLE FOUR

Available soil moisture (0-120 cm depth) as affected by snow management practices (1972-1979)

Year	Uniform Stubble (cm) Fall	Spring	Difference	Non-uniform Stubble (cm) Fall	Spring	Difference
1972-73	4.39	7.96	3.57	3.10	9.40	6.30
1973-74	- .41	7.04	7.45	-1.63	6.52	8.15
1974-75	4.82	9.09	4.27	4.06	8.74	4.68
1975-76	4.32	5.48	1.13	3.42	5.88	2.46
1976-77	3.98*	7.12*	4.14*	-0.77	10.51	4.52
1977-78	.15	6.08	5.93	-1.40	9.72	11.12
	0.60**	5.50**	4.90**	3.98**	10.96**	6.98**
1978-79	1.03	7.24	6.21	0.93	6.40	5.47
Average			4.67			6.00

Mean difference in available moisture = 1.43 (significant at the 5% level)
* Estimated from adjacent rotation studies on South Farm
** Large field-scale private farm observations near Swift Current
Source: Nicholaichuk.[3]

This added available moisture will allow the farmer to seed his stubble acreage more often. A good rule of thumb has been coined: Approximately one-half of the winter snow-fall can be trapped by stubble management techniques. On average, the amount stored as soil moisture is approximately one-half the amount trapped.

Two competitive barriers are shelterbelts and tall wheatgrass barriers. Shelterbelts are somewhat inconsistent for snow conservation but are very effective in reducing wind velocity. A dense belt of trees, 7.6 m in height will cause a reduction in wind velocity and evaporation to a distance of over 120 m on the lee side.

Tall wheatgrass barriers show the highest profit potential of all the barrier systems - competitive and non-competitive. Most of the research into tall wheatgrass barriers has been performed by U.S. scientists in Montana over the last 10 to 15 years. Canadian research in

Swift Current and Brandon has obtained similar results to the U.S. studies.

Long-term studies have shown that after the first 9 months of fallow, grass barriers had increased soil water storage nearly 100% over areas not protected by barriers; and 50% compared to the 21 month summerfallow period. The relative soil water recharge for continuously-cropped strips within the barrier system after the first winter (9 months) compared to conventional summerfallow (21 month period) outside the tall wheatgrass system ranged from 95 and 118% over the 8 year period.

This leads to the economics of using managemelt. The following criteria was used to analyze the potential profitability.

- a 44 kg/cm gain in yield can be achieved for each additional cm of water stored above a base of 8 cm.

For grassy barriers these were also used:

- major investments in equipment and other fuel factors were not included.
- only those costs and returns that vary between conventional crop-fallow and the experimental managemelt practices were considered.

The results of these economic analysis are summarized in Table Five.

TABLE FIVE

Economic analysis of snow management practices

Method of Snowmanagement	Net Economic Benefits/ha*
Noncompetitive Barriers	
Snow windrowing	-$ 5.75 to +$ 6.25
Swathing at alternate heights	$34.00
Competitive Barriers	
Shelterbelts	$ 8.60
Grass Barriers	$25.00 to $50.00

* Based on a grain crop value of $181/tonne and average costs of establishing and maintaining barriers.
Source: Nicholaichuk.[4]

Managemelt depends on conservation tillage and zero-incorporation to work. The two primary advantages of this CFP cornerstone are increased snow trapping and soil protection through the winter and spring. In years when adequate snow can be trapped it translates into increased soil moisture and, most important, increases yields. In years when snowfall is inadequate, chem-fallow/conservation tillage options must be exercised.

4. Flexible Cropping

The fourth cornerstone of the CFP system is flexible cropping. Once the "extra" moisture is trapped using conservation tillage, zero-incorporation and managemelt techniques it is critical to utilize the moisture. If it is not, the problems of run-off, saline seepage will continue to spread reducing productivity. The entire concept of flexible cropping focuses on soil moisture levels.

Flexible cropping involves the decision whether to seed a crop by calculating the overall moisture available including stored water and anticipated precipitation. It depends on efficient soil water management, adequate fertilization and generally good soil and crop management.

How much moisture is enough? To successfully re-crop, a minimum of 16 to 22 cm of plant-available water from both stored soil moisture and rainfall is required. Of that amount, the stored moisture in the root zone must account for at least 7.5 to 10 cm.

Some judgement of the soil type and its water holding capacity are necessary. Plant available moisture is estimated from the depth of moist soil according to soil texture. Medium and fine soils can hold about 8.3 cm of moisture per meter of soil (1 inch per foot), silt loams and clay loams about 16.6 cm of moisture per meter of soil (2 inches per foot).

Table six offers a good approximation of available water (inches) per foot of soil depending on soil texture.

TABLE SIX

Approximate plant-available water per foot of moist soil, and depth of moist soil needed for various amounts of water.

Texture	Texture	Plant-available water	Depth of moist soil for available water of 2 in.	4 in.	6 in.
Class		(in./ft.)	(in.)	(in.)	(in.)
Coarse	- fine sand - loamy sand	0.8	30	60	90
Medium Coarse	- sandy loam - fine sandy loam	1.5	16	32	48
Medium Fine	- loam, silt loam - clay loam - silty clay loam - silty clay - clay	2.0	12	24	36

Source: Brown et al.[5]

To use this table, the farmer would measure the distance of moist soil on the probe, and estimate his soil type. For example, if there are three feet of moist soil on the probe, and the soil is of a medium course texture, the plant available water would be: 3 x 1.5" = 4.5"

After estimating available soil water, the average growing season rainfall for the area should be determined. Farmers are well advised to seek professional advice from their local agriculture extension personnel or soil specialists in this regard.

Once the moisture calculations are made what are the options available? If there is not enough water then some form of conservation tillage will be required. If there is enough moisture a large number of choices can be made depending on the amount of available moisture.

There are many criteria to help decide which rotations to go with. One of these is the knowledge of how effectively, and to what depth the previous crop in the rotation depleted the water supply. It has been suggested succeeding crops should have deeper rooting depths. This type of rotation should continue until the depth of removal is greater than the recharge capacity.

Other factors in the crop choices must include considerations for disease, insect and weed infestations. also adequate fertilization is highly important and will vary depending on crop and soil type.

Flexible cropping involves careful management and planning. The optimal plan is to seed when stored water and probable rainfall are favorable for successful yields and to exercise conservation tillage when losses are predictable. By reducing fallow by 40% this could generate an additional $2 billion in small grain production.

This concludes the final cornerstone of CFP. As a system CFP appears to have great potential - both from an agronomic and a profit point of view.

In summary the CFP book is based on two arguments. The first argument is against the existing system. The second, the use of CFP. There is no question that todays soil problems are caused by intensive tillage and the use of crop-summerfallow rotation.

CFP offers the short-term benefit of favorable economics with the long-term benefit of maintenance of a rich soil resource. One of the simplest and easiest conversions to the CFP system is zero-incorporation.

The long-term perspective is to improve soil quality. Key elements in this are to increase the organic matter and thus the available nitrogen.

To increase erosion protection through conservation tillage. To halt the spread of salinization and to re-claim lost land.

The final element is that this improved soil quality will reap financial rewards. This includes direct saving from conservation tillage to the returns from extra land in production. It also includes the benefits of improved soil quality.

Conservation tillage and zero-incorporation offer the greatest savings without requiring major modifications to their present farm system. More advanced management techniques are required for the other two cornerstones; managemelt and flexible cropping. There is no question that the CFP system represents a third wave of farm practice evolution. This management system is a viable, economical and realistic alternative.

D.R. Strilchuk
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APPENDIX ONE

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1. Rennie et al, 1976.
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